UNLOCKING SCIENCE HANDS ON!

HOLDING THE HEAT

God has made our world from an amazing variety of materials. Whether we are looking at the atoms that make up everything around us or the molecules made of those atoms, they all have unique properties. One of those properties is called the specific heat. This is a measure of how much energy it takes to raise the temperature of one gram of a substance by one degree. Some substances absorb heat very quickly and have a relatively low specific heat. Other substances absorb heat very slowly and have a high specific heat. We take advantage of this property in many different ways. If you want to fry an egg, should you choose a material that heats up quickly or slowly? If you are hungry, you want it to happen fast. And if it takes less energy, then you save that energy and that cost to produce or pay for it.

Because God has made our planet out of water, rocks, vegetation, ice, and other substances that all have different specific heat values, our world has an amazingly stable balance of temperatures, winds, and other properties that help sustain life.

Extra Family Fun: Make some s'mores in the microwave or on the stovetop. Talk about which substances melt faster and how that relates to specific heat.

Heat Capacity Cups

Supplies

- 2 plastic cups
- Small piece of wood
- Thermometer(s)
- Sand
- Water
- Scale

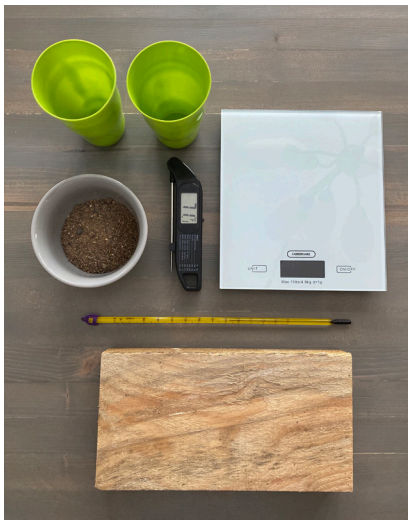


Figure 1: Supplies

Preparation

1. Turn on your scale and set the units to grams (g).
2. Place one of the cups on the scale and add sand to the cup so it is about half full. Record the mass of the cup and sand. Mass of sand =
3. Place the second cup on the scale and add water to the cup until it is the same mass as the sand cup. Mass of water =
4. Allow the cups to sit in the same space indoors so they come to the same temperature. Use the thermometer(s) to check that the temperatures are close to one another.
5. The piece of wood just needs to be large enough to place both of the cups on as you run the experiment.
6. If you have two thermometers, place one in each cup to monitor the temperatures. If using a digital thermometer, set it to read in Celsius.

Figure 2: Experimental Setup

Activity: Comparing Specific Heat

This activity will require you to monitor temperature for several hours in the morning and several hours in the evening (and all through the day if you desire). It will work best on a warm, sunny day where temperatures will be above 25°C (77°F). You will be determining if the sand or the water heats and cools faster. Write a hypothesis to predict whether you think the sand or the water will heat and cool faster.

Hypothesis: If the same mass of sand and water are heated by the sun, then _____.

Hypothesis: If the same mass of sand and water are cooled, then _____

_____

1 Find a place that will receive sun through most or all of the day.

2 Using the two cups that you prepared, place the cups on top of the wood in a sunny place.

3 Record the starting temperature in the 0 min. row. If you only have a thermometer that reads in Fahrenheit, use this formula to convert to Celsius: (°F – 32) / 1.8 = °C

4 Record the temperature every 15 minutes for 2 hours in the Morning (Heating) rows. If you only have one thermometer, make sure you allow 30 seconds or so to let the temperature stabilize between the samples. You may want to set a timer to remind you when to record your data.

5 You may also choose to record the temperature every hour through the day to extend the data. At the least, record the temperature during the hottest part of the day.

6 Determine when sunset wil be and begin recording the temperature during the cooling period 30 minutes before sunset in the 120 min. Evening (Cooling) row. Record the temperature every 15 minutes for 2 hours. (Alternatively, after you reach a stable maximum temperature, you can move the experiment to a cooler location or inside and monitor the cooling for 2 hours.)

Temperature Data Collection

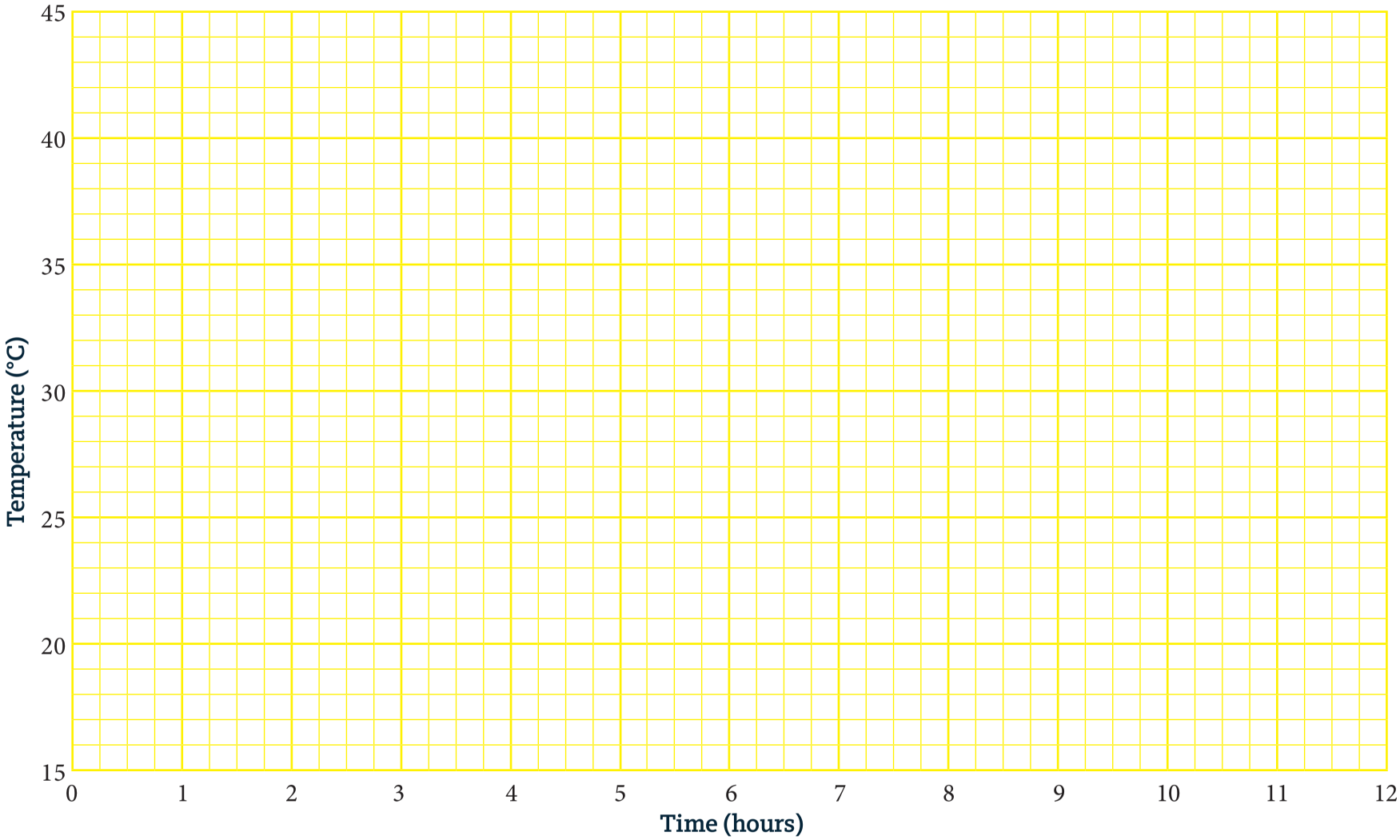
Morning (Heating)	Sand °C	Water °C	Evening (Cooling)	Sand °C	Water °C
0 min.			120 min.		
15 min.			105 min.		
30 min.			90 min.		
60 min.			75 min.		
75 min.			60 min.		
90 min.			30 min.		
105 min.			15 min.		
120 min.			0 min.		
3 hrs.					
4 hrs.					
5 hrs.					
6 hrs.					
7 hrs.					
8 hrs.					
9 hrs.					

Analysis Questions and Discussion

Use the data from your experiment to create a graph of the data. This will make analysis of the data easier. Use two different colors to mark the temperature data for the sand and water. Color the dot next to each label with the appropriate color. (Alternately, you can put your data into a spreadsheet and generate a graph.) Use the data to answer the questions.

Temperature Data Graph

○ Sand ○ Water



Comparing the data in the table:

1 Controlled variables are the things in an experiment that were the same for both cups. What were the controlled variables in your experiment? What things did you keep the same? *Both of the cups should have been identical; the cups were both placed in the same spot with the same sunlight; both cups were placed on the board; both cups were cooled at the same rate; the thermometers were the same; etc. The more similar the conditions of the two specimens, the more accurate the results will be.*

2 The independent variable (IV) in an experiment is the difference assigned by the experimenter. To identify the IV you can ask the question, "What was different between the different samples that were tested?" What was the IV in this experiment? *The difference was the type of substance that was measured—sand or water. The experimenter independently chose the substances to use. You could repeat this experiment with any other substance, changing the IV. Another IV was the amount of time the substances were left in the sun. The experimenter can independently choose how long to leave the specimens in the sun.*

3 The dependent variable (DV) in an experiment is the value that changes as a result of the conditions of the experiment. The DV changes as a result of the of the IV, and the DV is the variable that is measured by the experimenter. What was the DV in this experiment? *The temperature change was measured and it was the amount of time that passed in the sun or out of the sun that caused the effect of temperature change. The time in the sun (IV) is the cause, and the temperature (DV) is the effect.*

4 What was the increase in temperature from your initial to peak temperature? *Results will vary, but the calculation is simply peak T – initial T = change in T.*

5 The data that you gathered was recorded in the table. Analysis happens when you look at the data and evaluate it or do calculations with it. Would determining the increase in temperature from the starting point to the peak temperature be data or analysis? *While the initial and peak temperatures were recorded, you have to do a calculation to determine the change, so this is an example of data analysis. You can look at the graph as a representation of the data, but analysis happens when you calculate an average, assign a line of best fit, or calculate the slope of the curve.*

6 After gathering data and analyzing it, the process of interpretation can begin. This generally involves using the data analysis to assess the hypothesis and explain the results. Did your data confirm or disprove your hypothesis? *The answer will depend on the hypothesis, but the sand should have heated up faster than the water and the sand should have cooled down faster than the water.*

7 Looking at the graph, was the slope of the graph positive (going up) or negative (going down) during the heating period? During the cooling period? Why did this happen? *The slope should have been positive (going up) during heating since the temperature was getting higher as more of the sun's energy was absorbed by the sand and water. The reverse is true during the cooling phase. As the heat is lost to the environment, the temperature goes down and the slope is negative. Older students could further analyze the data by determining a line of best fit and slopes of different sections of the graph.*

8 Thinking about the data you have collected and analyzed, does sand or water have a higher specific heat? *Since the sand heated faster, it has a lower specific heat than water. The value for silicon dioxide, the major component of sand, is 0.680 J/g°C while the value for water is 4.187 J/g°C. Joules (J) is the measure of energy, so it takes almost 6 times as much energy to raise the temperature of equal masses of water and sand. That is why the sand temperature rose faster when they received the same amount of energy from the sun.*

9 How can studying a topic like specific heat offer an opportunity to praise God? *Understanding how God has made so many different substances can help us understand how powerful and creative he is. Knowing that these values never change reminds us of God's attributes that never change. We can thank him for creating substances with different properties to use in different instances.*

They shall not hunger or thirst,
neither scorching wind nor sun shall strike them,
for he who has pity on them will lead them,
and by springs of water will guide them.
Isaiah 49:10 (ESV)

